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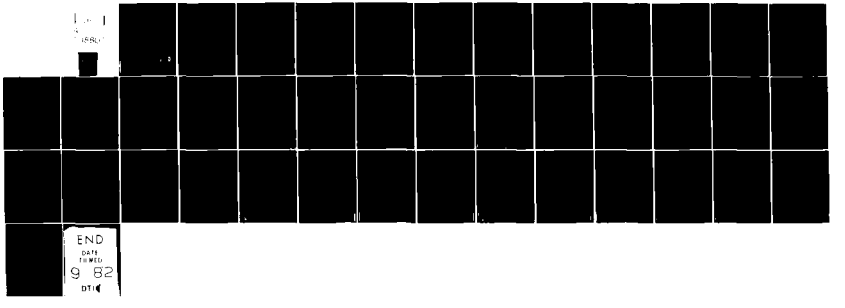

UNCERTAINTY IN ESTIMATING POWER-PLANT CLOSURE COSTS: A REVIEW OF "ECONOMIC IMPACT OF CLOSING ZION NUCLEAR FACILITY," A REPORT BY THE COMPTROLLER GENERAL OF THE UNITED STATES

James P. Stucker

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ABSTRACT

Comparing GAO's estimates of the costs that could result from the closure of Zion and Indian Point reveals the large range of uncertainty currently associated with such estimates and suggests a number of areas requiring further study. Better and more detailed information on alternative generating costs, decommissioning costs, incremental financing costs, and secondary costs in general needs to be developed and documented. And the groups or institutions who will ultimately bear these costs need to be identified. Uncertainties in all these areas must be reduced, and common costing methods and assumptions adopted, before intelligent decisions can be made regarding the future of any of the nuclear generating facilities (either operational or under construction) that are currently being questioned.

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UNCERTAINTY IN ESTIMATING POWER-PLANT CLOSURE COSTS: A REVIEW OF "ECONOMIC IMPACT OF CLOSING ZION NUCLEAR FACILITY," A REPORT BY THE COMPTROLLER GENERAL OF THE UNITED STATES

James P. Stucker*

The March 18, 1979, accident at the Three Mile Island (TMI) nuclear power plant raised serious questions as to the advisability of siting nuclear facilities near large population centers. Since then, the Nuclear Regulatory Commission (NRC) has been reviewing power plant siting criteria and the safety records of individual plants. The Indian Point facility near New York City and the Zion facility near Chicago have received special attention. Comprehensive studies of conditions in and around both plants have been ordered.

As part of that investigation, the Chairman and the Ranking Majority Member of the Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce, requested that the General Accounting Office (GAO) undertake a comprehensive analysis of the costs of terminating the operation of the Indian Point and Zion plants.[1]

In response to the request, GAO recently published its analysis of the economic costs of closing the Zion facility.[2] The Zion report--

*The Rand Corporation, Santa Monica, California. Thanks to Lynn Batten, Brent Bradley, Bill Mooz, and Ken Solomon for many helpful comments and suggestions.

[1]Letter of April 10, 1980, from The Honorable John D. Dingell and The Honorable Richard L. Ottinger, reproduced as Appendix 1 of the Zion report cited below.

[2] Economic Impact of Closing the Zion Nuclear Facility, Report by the Comptroller General of the United States, EMD-82.3, U.S. Govern-

like the Indian Point report before it[3]--contains estimates of the direct, economic costs that would be incurred if the nuclear facility were to be shut down and decommissioned immediately.

The GAO reports on Indian Point and Zion represent the state of the art in estimating closure costs for nuclear power plants. The Indian Point report, issued in November 1980 as the first of its kind, was a pathbreaking work. But, like all initial efforts, it addressed more issues than could be answered at that time. The Zion report, expected soon after the Indian Point report, but delayed until October of 1981, attempts to resolve some of those issues. It obviously builds on the knowledge and procedures developed for the Indian Point report and on several criticisms of that study.[4] However, these studies are so new and the costs associated with nuclear power plants are so elusive that significant uncertainties remain.

Many significant, and even critical, issues and assumptions still need to be identified, discussed, and quantified. The Indian Point and Zion reports attempt to make point projections of total closure costs,

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ment Printing Office, Washington, D.C., October 21, 1981. Hereafter cited as the Zion report.

[3] Economic Impact of Closing the Indian Point Nuclear Facility, Report by the Comptroller General of the United States, EMD-81.3, U.S. Government Printing Office, Washington, D.C., November 7, 1980. Hereafter cited as the Indian Point report.

[4] Carolyn Kay Brancato, "The Indian Point No. 2 Nuclear Facility," Congressional Research Service, Washington, D.C., December 5, 1980. Vince Taylor, and Charles Komanoff, An Evaluation of "Economic Impact of Closing the Indian Point Nuclear Facility," A Report of the General Accounting Office, Union of Concerned Scientists, Cambridge, Massachusetts, December 3, 1980. For a comparative analysis of these three studies of the Indian Point facility, see James P. Stucker, Charles L. Batten, Kenneth J. Solomon, Werner Z. Hirsch, Costs of Closing the Indian Point Nuclear Power Plant, The Rand Corporation, R-2857-NYO, November 1981.

but a comparison of the findings of the two studies reveals that the magnitude of the uncertainty associated with cost studies of this type is very large: GAO projects that the extra costs incurred during the first six years after closure would be over $9 billion for Indian Point (with a capacity of 1,836 megawatts) and less than $2 billion for Zion (with a capacity of 2,080 MW).

Differences of this magnitude reduce our confidence in either estimate and indicate that much more research must be undertaken before rational public policy decisions can be analyzed for either Indian Point or Zion.

This paper is my second publication on the nature, scope, and magnitude of power plant closure costs. Earlier, I summarized the several studies concerned with Indian Point's closure costs and synthesized a total cost estimate, and an associated range of uncertainty, for that facility.[5] In this paper I focus first on GAO's estimates for Zion, and then compare those with its earlier estimates for Indian Point. In particular, I organize and summarize the major components of cost for closing Zion, and then compare those estimates, item by item, with the estimates for Indian Point.

To summarize my major conclusions here, I find 6 areas where major cost uncertainties currently exist:

- o A theoretical framework for costing power plant closures is the most pressing need if rational discussions are ever to be held on the future of the nuclear facilities.

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[5] Stucker, Batten, Solomon and Hirsch, op. cit.

- Replacement power costs are the most significant direct costs and require careful treatment. GAO estimates these costs at over $1.5 billion (in 6 years) for Zion and at more than $4 billion for Indian Point. Replacement power costs usually need to be estimated by the utilities or someone working directly for them, but the work needs to be of the highest quality and fully documented if it is to be used in the public decision-making process.

- Since no large nuclear facilities have so far been closed, we have no experience with decommissioning costs and they could easily turn out to be much higher than is now believed. TMI should eventually provide an excellent case history of the varieties, evolution, and causes of these costs.

- Increased financing costs may turn out to be the most important costs associated with forced closure of nuclear plants. Closure of a nuclear facility will undoubtedly increase the financial risk for the utility, and the risk premiums demanded by investors. GAO includes over $5 billion in incremental financing costs in the Indian Point estimate, but leaves them out of the Zion calculations.

- Closure activities and the associated higher cost of electricity will induce secondary effects. These costs will impact in unknown ways on many social and economic groups other than the immediate stockholders, bondholders, and ratepayers of the utility.

- Finally, the full regional and socio-economic distribution of costs (and benefits) is both highly uncertain and potentially quite sensitive politically. The distribution of effects is also highly interesting from an economic viewpoint because (1) each possible distribution will provide a different pattern of winners and losers among the user, supplier, and owner groups, (2) some distributions may affect the net level of closure costs, and (3) nearly all distributions will have serious implications for the future of the utility industry.

All of these areas currently contribute to the uncertainty associated with estimating closure costs for nuclear power plants. These, and possibly more, issues must be directly addressed before rational decisions can be made concerning the future of nuclear power plants whether they are called Indian Point, Zion, TMI, Diablo Canyon, or something else.

The sections below present the rationale for those conclusions. Section I describes the Zion costs. Section II compares the Zion and Indian Point estimates and attempts to determine the causes of the major differences. Section III summarizes the findings and presents the conclusions of the study. The Appendix provides detail on the GAO's discussion of total revenue requirements for Zion and contains a reconciliation of several of its estimates of those requirements.

I. THE ZION REPORT

The Zion nuclear facility is located about 40 miles north of Chicago on the western shore of Lake Michigan. Owned by Commonwealth Edison Company, it consists of two identical pressurized water reactors furnished by Westinghouse Electric Corporation. Zion began operation in 1973 at 85 percent power, and in June 1976 the NRC authorized full power operation.

Commonwealth Edison is an investor-owned utility company engaged in the production, purchase, transmission, distribution, and sale of electricity.[1] It is one of the largest electric utilities in the country, with a total gross utility plant of $12 billion, including construction work in progress of $4.1 billion. Commonwealth Edison's electric service territory covers about 11,525 square miles of northern Illinois, with an estimated population of 8 million. In 1980, the utility sold 62.2 billion kilowatt hours (kWh) of electricity to its 2.9 million customers and collected $3.3 billion in revenues.[2]

In 1980, Commonwealth Edison generated over 63 billion kWh of electricity from its power plants. Of this amount, about 12 billion kWh or almost 19 percent, came from the two Zion nuclear units. The cost of electric service charged to customers from the Zion station was 3.3 cents per kWh compared to 5.0 cents per kWh for energy produced from coal units, 12.3 cents per kWh for steam-oil units, and 19.8 cents per

[1] Commonwealth Edison currently operates three nuclear facilities--Dresden, Quad-Cities, and Zion--with total capacity of 4,778 MW, and expects to open 6 additional units with 6,515 MW of capacity between 1882 and 1986.

[2] The Zion Report, p. 1.

kWh for peaking units.[3]

GAO's analysis of the potential economic impact of closing Zion discloses that:

- The loss of Zion would reduce Commonwealth Edison's reserves below levels considered adequate for maintaining reliable service.
- Commonwealth Edison's production costs would increase by more than $300 million during the first year without Zion.
- Ratepayers would be assessed an additional $47 million to $356 million, depending on which costs the Illinois Commerce Commission (ICC) allows in the rate base.
- Commonwealth Edison's increases in revenue requirements through the year 2000 could total between $16.6 billion and $18.2 billion.[4]

Closing Zion would thus cause Commonwealth Edison either to purchase replacement power from other utilities or to rely on higher-cost generation from its own limited facilities and risk shortages or brown-outs during periods of peak demand or unscheduled maintenance of the other units.

Many different types of costs would be incurred if a producing nuclear-powered electricity generating facility should be shut down. Study of the Zion and Indian Point reports, however, reveals that we can reasonably group all of the costs into four broad categories:

1 Generating costs;

2 One-time costs;

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[3] Ibid., p. 7.
[4] Ibid., p. i.

3 One-time savings; and

4 Other costs.

Each category of cost may be important in determining total closure costs. I will discuss each category separately below and show my interpretation of the GAO's estimates for Zion. The GAO's most detailed work covers the 1981-1986 period, a period that apparently coincides with the latest planning studies of Commonwealth Edison. This is a very short and quite arbitrary period for policy analysis since the effects of the closure would probably be felt until well into the next century (when the Zion units are scheduled to be closed), but it is apparently the period for which data are available. Fortunately, data for Indian Point are available for the same period, so direct comparisons can be made.

Generating Costs

Generating costs include all of the extra costs resulting directly from producing the required electricity at another (more costly) facility after the nuclear facility in question is shut down. For Zion, GAO estimates these costs will total $1.5 billion to $1.8 billion during the first 6 years of closure.

Because of its large capacity and low operating costs, Zion generates more electricity than any other Commonwealth Edison station. Removing Zion from service would require Commonwealth Edison to generate more electricity at its fossil-fired plants and to substantially increase its purchases of power from other utilities. The GAO estimates that replacing Zion's low-cost generation with those other sources would

increase production costs by over $300 million in 1981.[5] From 1981 through 1986, annual production cost increases would amount to nearly $1.8 billion if production is assumed to increase at an annual compound rate of 3 percent (see Table 1), and nearly $1.6 billion if the annual rate of load growth is 1.5 percent[6].

Table 1

GAO' s Estimate of
Generating Cost Increases If Zion is Closed

(millions of dollars)

Year	1.5-percent load growth	3-percent load growth
1981	$ 312	$ 313
1982	286	280
1983	274	294
1984	246	288
1985	208	268
1986	258	335
Total	$1,584	$1,778

SOURCE: Zion report, Table 17, page 26.

[5] Commonwealth Edison produced these estimates using Energy Management Associates, Incorporated's PROMOD III, a computerized production cost and reliability model for electric utilities. The program determined which generating units would be used to meet weekly loads, taking into account the order in which units are to be committed, scheduled maintenance, probability of forced outages, and other factors. (p. 20)

[6] GAO presents data showing that the average annual growth rate of peak load was nearly 3 percent (compounded) from 1971 through 1980. Annual changes differed greatly, however, apparently responding both to the state of the economy and the weather. GAO uses the 1.5 rate to illustrate the sensitivity of predicted costs to future demand. (pp. 20-21)

With the Zion units in service, Commonwealth Edison's basic generation mix will become increasingly focused on nuclear power over the next few years as new nuclear units now under construction come into service. Zion's generation from 1977 to 1980 averaged 11.7 billion kWh, the maximum occurring in 1978 at 13.5 billion kWh. For 1981 through 1986, the Zion units' generation is projected to average 11.6 billion kWh under the 3 percent load growth assumption and 11.3 billion kWh assuming 1.5 percent growth. The loss of the Zion units would place a larger load on Commonwealth Edison's fossil-fueled units, but most of Zion's lost generation would need to be made up with purchased power.

The production cost estimates in Table 1 are based on the assumption that significant amounts of additional firm purchased capacity--as much as 2,080 MW in the early years--would be available so that Commonwealth Edison could maintain its 15-percent reserve margin objective.[7]

One-Time Costs and Savings

One-time costs include all of the costs associated with decommissioning the nuclear facility, disposing of the spent fuel, and terminating contracts. GAO notes that although a few small nuclear reactors have been decommissioned in the United States, no major facility the

[7] Commonwealth Edison is a member of the Mid-America Interpool Network (MAIN), one of the nine regional councils of the National Electric Reliability Council, whose purpose is to augment the reliability and adequacy of the bulk power supply of the electric utility systems in North America. Although MAIN's membership includes electric power systems in upper Michigan, Wisconsin, Illinois, and Missouri, Commonwealth Edison is the largest member, accounting for about 40 percent of MAIN's 41,648 MW capability. In 1980, Commonwealth Edison's net purchases were 4,184,563 megawatt hours of electricity. (Ibid., pp. 3-4)

size of Zion has been decommissioned. Available cost estimates, therefore, are tentative and subject to a number of uncertainties.

Based on studies sponsored by the NRC, Commonwealth Edison estimates that decommissioning the two Zion units using the dismantlement method would cost $113 million, in 1981 dollars, spread over a period of 6 years.[8] Since they have already collected some $40 million from ratepayers for that purpose, the extra costs to be incurred would be about $73 million.[9]

The GAO itself estimates the cost of disposing of the spent fuel from Zion. Using information from the U.S. Department of Energy, GAO estimates the cost of temporary storage of the spent fuel from Zion to be $65 million and the cost of later permanent disposal to be $133 million (both estimates in 1981 dollars). GAO seems to suggest that a permanent disposal site would become available at about the time that Zion would, under normal or planned conditions, become obsolete and be decommissioned and thus that the $65 million represents the incremental cost of early closure.[10] I cannot determine how much of this is expected to accrue in the first 6 years of closure or how much Commonwealth Edison is already collecting each year for this purpose, but the estimate is obviously small relative to the other items considered by GAO. I include $10 million in Table 2 simply to illustrate the relative magnitude GAO apparently attributes to this item.

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[8] Ibid., p 33.

[9] These costs represent expenses that would be incurred eventually whether Zion is closed immediately or not; they are not incremental to the act of premature closure. I include them here because they do represent changes in the costs that would be incurred during the 1981-1986 period.

[10] Ibid., p. 34.

Table 2

GAO Estimates of Changes in One-Time Costs and Savings
That Would Be Incurred in the First Six Years of Closure at Zion

Item	Millions of 1981 dollars
Costs of closure	
Decommissioning costs	
Dismantling	73
Disposal of spent fuel	10
Write-offs	
Loss on future fuel commitments	28
Total nonrecurring costs	111
Savings from closure	
Major plant additions and required safety modifications	138
Radiological emergency response measures	7
Chemical cleaning facilities and services	31
Total nonrecurring savings	176
Net nonrecurring costs of closure	(65)

SOURCE: GAO Zion report.

Finally, GAO reports that Commonwealth Edison personnel estimate that about $28 million would be lost on future fuel commitments: losses of $20 million would be incurred for two refuelings scheduled for late 1981 and early 1982; a $5 million penalty would be incurred to cancel a conversion contract for uranium enrichment; and carrying charges would increase by $3 million as uranium intended for Zion fuel is used elsewhere at a later date.[11] Total one-time costs incurred in the first 6

years of closure would thus be about $111 million 1981 dollars, or less than one-tenth the size of the incremental generating costs that GAO estimates would be incurred over the same period.

Table 2 also shows the one-time savings that might result from closing Zion. One-time savings represent the now-planned activities and back-fits that would not be needed if the nuclear facility is shut down. They also turn out to be relatively small: Commonwealth Edison plans to spend $138 million over the next 5 years for additions to the plant; radiological emergency response plans for the Zion plant are expected to cost the utility about $7 million over the next 5 years, with relatively minor additional costs being borne by Federal, State, and local governments; and chemical cleaning costs are estimated at about $31 million. All of these costs can be avoided if Zion is closed. GAO indicates that additional expenditures, uncertain at this time but possibly large, may also be required by NRC resulting from its review of nuclear stations near densely populated areas.[12] Without those costs, however, one-time savings total only about 10 percent of the estimate of incremental generation costs.

Other Costs

Other costs include all of the remaining cost items that are not covered in the above three categories. GAO does not display these costs separately, but goes directly from generating costs to its concept of total closure costs. To isolate these costs for Zion, then, we must subtract GAO's estimate of generating costs (and several of the one-time

[11] Ibid., p. 38.
[12] Ibid., pp. 11-12.

cost and saving items) from its estimate of total closure costs.

As its total cost concept GAO defines the incremental change in "total revenue requirements" for Commonwealth Edison from closing Zion, which it claims "reflect the full financial impact of closing Zion."[13] These requirements are the sum of operating expenses, depreciation expense, taxes, interest, and return on investment.[14] The generating cost increases, discussed previously, represent the most immediate cost impact of shutting down the Zion units. Loss of the units, however, would also affect the other cost elements.

To investigate the effects of closure on the depreciation and return on investment items, GAO goes to great length adding and subtracting various specifications of those items to generating costs and displaying alternative estimates of revenue requirements. I discuss a number of the more interesting estimates and reconcile the major ones in the Appendix to this paper. Here I will only show my calculation of the other cost estimates. Readers seeking more information on these costs or on GAO's concept and analysis of total revenue requirements should consult the Appendix.

At GAO's request, Commonwealth Edison projected total revenue requirement increases through the year 2000, assuming the Zion units were taken out of service in 1981. Table 3 shows these projections under the two alternate growth assumptions. In these projections, costs of the Zion plant are treated as sunk costs (depreciation expense and return on investment continue as they would with Zion in service) and

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[13] Ibid., p. 18.
[14] Ibid., p. 27.

Table 3

GAO Estimates of Increases in Total Revenue Requirements With Zion Out of Service

(millions of dollars)

Year	1.5-percent load growth	3-percent load growth
1981	$ 311	$ 312
1982	276	269
1983	262	283
1984	351	398
1985	188	254
1986	239	326
1987	246	409
1988	281	461
1989	338	467
1990	416	707
1991	499	1,100
1992	618	1,352
1993	819	1,359
1994	1,147	1,379
1995	1,406	1,379
1996	1,660	1,474
1997	1,867	1,429
1998	1,729	1,622
1999	2,023	1,417
2000	1,906	1,798
Total	$16,582	$18,194

SOURCE: Zion report, Table 28, page 37.
NOTE: Detail may not sum to total due to rounding.

decommissioning costs are included in 1984 revenue requirements.

Comparing the total revenue requirements of Table 3 with the estimates of alternative generation costs from Table 1, we see that total revenue requirements are almost always smaller than the generating costs. In only 2 of the 12 possible comparisons are revenue requirements higher than generating costs, and then only slightly. Both those

cases are for 1984 when decommissioning costs are added in. So even though the utility is allowed both return on investment and an accelerated write-off of the closed facility, the projected revenue requirements fail to cover the incremental generation costs.

The implication of this finding is that Commonwealth Edison's concept of total revenue requirements does not match up with the concept of total closure costs implicit throughout the rest of the Zion report. It includes few of the one-time costs and savings identified above and apparently none of the incremental financing costs or secondary costs of any variety.[15] We will see how truly atypical this estimate is in the next section, when we compare it with GAO's estimate for Indian Point.

To isolate an estimate of other costs for the first 6 years of closure (see Table 4), I summed the entries in Table 3 for 1981 through 1986, and then increased the total by $35 million to represent the (inflated) loss on future fuel commitments[16] and $98 million, representing reduced tax revenues to local governments ($13 million per year compounded at 9 percent). I also subtracted $220 million to allow for the (inflated) one-time savings that would be realized if Zion was closed. This produced an adjusted and more defensible estimate of total closure costs. I then subtracted the (inflated) estimates of generating costs and one-time costs and savings, taken from Tables 1 and 2 respectively, to obtain the estimate of other costs. This estimate ranged

[15] Note that the estimates in Table 3 represent the largest estimates of revenue requirements contained in the Zion report. The Appendix reports the other estimates, all of which are smaller than the ones discussed here.

[16] I inflated all of the one-time cost and saving estimates by 25 percent to represent 9 percent inflation over the 6 year period.

Table 4

Derivation of Estimates for the Other Costs of Closing Zion: First 6 Years of Closure

(millions of dollars)

Item	1.5-percent load growth	3-percent load growth
Revenue requirements	1,627	1,842
Fuel commitments	35	35
Local property taxes	98	98
Savings from closure	(220)	(220)
Total closure costs	1,540	1,755
Less:		
Generating costs	1,584	1,778
One-time costs	139	139
One-time savings	(220)	(220)
Other costs	37	58

SOURCE: Tables 1 through 3.
NOTES: Fuel commitment cost was inflated from $28 million and taxes inflated from $78 million to allow for inflation of 9 percent per year. One-time costs and savings were similarly adjusted.

from $37 million in the 1.5 percent growth case to $58 million in the 3 percent growth case.

In Sec. II below I compare these estimates of GAO's other costs for Zion with the (much larger) estimates that GAO produced last year for Indian Point.

II. TOTAL CLOSURE COSTS FOR ZION AND INDIAN POINT

We might think that the GAO-estimated costs for Zion and for Indian Point should be nearly equal. The situations at the two sites appear to be comparable. The capacity of the Indian Point units is 1,836 MW, with a lifetime cumulative capacity factor through June 1980 of 57 percent. So the closure of Indian Point would require the replacement of, on the average, 9.17 billion kWh of electricity per year.[1] The Zion units with a capacity of 2,080 MW produced 11.8 billion kilowatt hours of energy in 1980.[2] We might expect, if anything, that closure costs for Zion would be larger than those for Indian Point. Furthermore, the Indian Point report says that the New York City area served by Consolidated Edison (ConEd) and the Power Authority of the State of New York (PASNY) currently has sufficient excess capacity to withstand the closure of Indian Point while retaining a reserve margin of over 20 percent.[3] Commonwealth Edison, on the other hand, is currently operating near the 15 percent margin it considers necessary, so if Zion were closed Commonwealth Edison would be forced to purchase nearly all of the replacement generation from other utilities. This again suggests that Zion's closure costs might be higher.

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[1] Taylor, Vince, and Charles Komanoff, An Evaluation of "Economic Impact of Closing the Indian Point Nuclear Facility," A Report of the General Accounting Office, Union of Concerned Scientists, Cambridge, Massachusetts, December 3, 1980.

[2] Zion report, pages ii and 1.

[3] ConEd owns and operates Unit 2 at Indian Point, supplying power to New York City and Westchester County. PASNY is responsible for Unit 3, which supplies power to municipal users in the area and to other utilities. PASNY also operates a number of other units throughout the state.

Comparing the Estimates

The costs summarized in Table 5, however, reveal that GAO expects the closure costs for Indian Point to be much greater than those for Zion. In fact, it estimates total costs for the closure of Indian Point to be over 5 times as high as the closure costs for Zion.

The derivation of the Zion costs was discussed above. The estimates shown in Table 5 for Indian Point come directly from the GAO report on that facility.[4]

Table 5

Comparison of Zion and Indian Point Costs
Incurred During First 6 Years of Closure

(billions of dollars)

Item	Zion		Indian Point
Growth Rate of Demand:	1.5 percent	3 percent	1.25 percent
Generating costs	1.58	1.78	4.17
One-time costs	0.14	0.14	0.45
One-time savings	(0.22)	(0.22)	(0.27)
Other costs	0.04	0.06	4.92
Total	1.54	1.76	9.27

SOURCE: GAO Zion report and GAO Indian Point report.
NOTES: Detail may not sum to total due to rounding. All costs are undiscounted and include allowances for inflation.

[4] Stucker, Batten, Solomon and Hirsch, op. cit., contains a detailed interpretation of the GAO's estimates for Indian Point. The generating cost estimate for Table 5 was taken from Table 3-8 on page 42 of the Indian Point report; one-time costs from page 56; one-time savings from page 57; and other costs from the data in Tables 3-8, 3-10, 3-12 and 3-13. Note that I lowered GAO's estimate of $83 million in spent-fuel disposal costs for Indian Point to $10 million and inflated

We have seen that the differences between the GAO estimates for Zion and those for Indian Point are not due to differences in the size or utilization of those facilities. Two other likely causes suggest themselves almost immediately: future growth rates of demand; and assumed inflation rates. But further study of the reports reveals that neither of those items is responsible either. As noted above, the GAO factored inflation into the Zion cost estimates at a rate of 9 percent a year; Appendix II of the Indian Point report indicates that similar rates were used in constructing the Indian Point estimates.[5] The growth rates of future demand for the two sites are also comparable, or even biased in favor of lowering Indian Point's relative costs. GAO assumed demand growth rates of 1.5 and 3 percent per year as the basis for the Zion estimates while estimates for Indian Point were based on an average annual rate of growth that I calculate to be less than 1.25 percent.[6]

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all other one-time costs and savings by 25 percent to make them comparable with the Zion estimates. The estimate of other costs was constructed in the following manner. Differencing Tables 3-13 and 3-12 yields Consolidated Edison's incremental revenue requirements for the full passthrough case (the case with the $18.7 billion requirement through 1994 that is reported in the summary). Subtracting ConEd's incremental generation costs as reported in Table 3-10 then yields ConEd's other costs. And factoring that up by the ratio of total (ConEd plus PASNY) generating costs (Table 3-8) to ConEd's generating costs for the 1981-86 period yields the full estimate of other costs. In the Indian Point study one-time costs and savings were not included in estimating total revenue requirements (p. 53).

[5] "The escalation rate assumed was a conservative 9 percent per year for low sulfur oils and 8.5 percent for higher sulfur oils (greater than 2 percent) through 1992." "All coal prices are estimated to escalate at 9.6 percent per year through 1985 and 7.2 percent thereafter." Indian Point report, pp. 73-74.

[6] Table 3-4 on page 35 of the Indian Point report shows that total available power for the ConEd franchise area is expected to be 35,814,564 megawatt hours in 1981 and 40,947,477 megawatt hours in 1992.

Differences in One-Time Costs and Savings

The differences in one-time costs, although small in relation to the differences in the other categories of cost, are significant. The estimate for Indian Point is over three times the size of the estimate for Zion. Investigation of the individual cost items (as listed in Table 2) reveals that GAO consistently estimated lower costs for Zion.

The same general trend holds for the estimates of one-time savings. GAO provides a lower, more conservative, estimate for Zion on each item of cost, although the totals for one-time savings differ by much less than do the totals for one-time costs. Clearly there are some unanswered questions here, but the major causes of the $7 billion dollar difference in the estimates of total closure costs must be found elsewhere.

Differences in Replacement Power Costs

Differences in replacement power costs account for just about one-third of the total difference in the estimated costs of closing Zion and Indian Point. GAO suggests that generating costs would be less than $1.8 billion for Zion over the first 6 years of closure while they would be over $4 billion for Indian Point over a similar period.

The Indian Point report shows incremental 1981 fuel costs of $607 million for the generation of the 9.17 billion kWh needed to replace the Indian Point generation.[7] That indicates a cost of about 6.6 cents per kWh. By contrast, actual generation costs for the Indian Point units were 1.2 cents per kilowatt hour for Unit 2 and less than 1 cent

[7] Indian Point report, p. 41.

per kilowatt hour for Unit 3 in 1979. In that same year, oil-fired generation costs were between 2.5 and 4 cents per kWh for the ConEd/PASNY system.[8] The large discrepancy between the cost of purchased and own-generated power would be due, at least in part, to ConEd and PASNY's limited transmission system and the requirement that they burn mostly low-sulfur fuel in their metropolitan units.

The Zion report projects that the replacement costs for the 11.6 billion kWh of electricity needed in 1981 would amount to just over $447 million. This gives a cost per kWh of about 3.9 cents, a very competitive price.[9] This assumption that Commonwealth Edison would be able to purchase replacement electricity at a cost which is 2.7 cents per kWh less than the price which ConEd and PASNY are assumed to pay for electricity to replace their lost generation at Indian Point is the primary determinant of the difference in generating costs.

Differences in the Treatment of Other Costs

We have seen that GAO estimated the "other costs" that might be associated with the closing of the Zion facility to be quite small. On the other hand, it estimated the other costs for the closure of Indian Point to be nearly $5 billion during the first 6 years of

[8] Indian Point report, p. ii. Fixed costs added about 1.5 cents per kWh to the Indian Point costs and 1.5 cents per kWh to costs for the conventional baseload units (p. 14).

[9] Table 1 of the Zion report indicates that the average 1980 generation costs incurred by Commonwealth Edison were 0.7 cents per kWh for the Zion units, 0.8 cents per kWh for its other nuclear units, 2.5 cents per kWh for the coal units, 6.4 cents per kWh for steam-oil units, and about 9 cents per kWh for the oil and gas peakers. Total costs ranged from 3.3 to 19.8 cents per kWh. (p. 8)

Closure.[10] This difference is even larger than the difference in the size of the replacement generation costs.

In the Indian Point report, GAO states that incremental revenue requirements for the utilities include (besides fuel costs) construction and financing costs and dividend payments.[11] Construction costs (incremental to the closing of Indian Point) appear to be a relatively minor item since the utilities have both excess current capacity and several projects already programmed to be on-line by 1987. But that is only my inference based on many readings of the report. The report contains nothing explicit at all on the composition of its "revenue requirements", other than the general definition given above.[12] There is little alternative, however, to inferring that these costs consist almost entirely of increased financing requirements.[13]

Taylor and Komanoff agree with this inference. They find that:

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[10] The $5 billion estimate is for the full-passthrough case and is directly comparable with the Zion estimates shown in Table 6. GAO also estimated a number of partial-passthrough cases for Indian Point, just as they did for Zion.

[11] Indian Point report, p. iv.

[12] Total revenue requirements for the Indian Point study were estimated for GAO by Stone and Webster, Management Consultants. The GAO report on Indian Point contains no documentation of that work.

[13] Note that I explicitly differentiate between the incremental construction costs and the incremental financing costs. Incremental construction costs include all of the increased real costs associated with moving construction dates for new power plants ahead because of the anticipated closure of one of the operating nuclear plants. Incremental financing costs include all of the increased financial costs, the increased returns that will be demanded in both the bond market and the stock market (on all, past as well as present, financing) if the utilities attempt to remain viable and to continue to supply electricity after one or more of the nuclear units is shut down. These costs reflect the changes in financial risk that investors would associate with the affected utilities.

> The figure [GAO estimate of incremental revenue requirements for closing Indian Point] was generated by a model that included as "costs of closing Indian Point" such items as a) higher rates of return on investment for Con-Ed, b) improved cash flow (accounting for over $2 billion of the $18 billion), and c) higher dividends to Con-Ed stockholders. These factors account for a major (but unspecified) portion of the total.[14]

GAO then has apparently changed its opinion of financing costs. In the earlier report (on Indian Point) it included changes in required rates of return to shareholders (and probably to bondholders) as legitimate closure costs. In the later report on Zion, GAO apparently includes none of those costs.[15] Since there is no explanation for the change, GAO apparently accepted the criticism of Taylor and Komanoff (and perhaps others).[16]

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[14] Taylor and Komanoff, p. 2.

[15] Note also that there are other categories of non-direct costs that are not discussed in either report. Regional impacts, other than the loss of 400 jobs and $13 million in property tax, are ignored, and the whole concept of secondary costs--the second, third, and later-round effects that are induced, or flow from, the imposition of the other costs (for example, increased electricity rates raise costs for businesses and households, which then alter their behavior and affect other economic units)--is not even mentioned.

[16] There exists, of course, the possibility that GAO simply believes that the Indian Point closure would involve $5 billion in additional financial costs while the Zion closure would not require any. The reserve position specified for Commonwealth Edison, however, does not justify any such belief.

III. SUMMARY AND CONCLUSIONS

GAO has constructed two cost estimates for closing large operational nuclear reactors before the end of their economic life. The first estimate is quite high, more than $9 billion dollars over the first 6 years of closure, and consists of $4 billion in replacement generation costs and $5 billion in increased financing costs. The second is much lower, less than $2 billion over a similar 6 year period, and is composed almost entirely of costs for purchasing substitute power.

The difference in the costs of replacement power may be due to actual differences in the physical and economic options available in the two areas, or it may be due entirely to ad hoc assumptions specified for the costing models. The reports don't specify which. Neither report documents its generating-cost model adequately or attempts to interpret, explain, or justify its output.

The difference in financing costs is also unexplained. In the Indian Point study, these costs were estimated by a consultant from Stone and Webster, and the GAO report contains little more than summary tables. The cost estimates presented in the Zion study that "reflect the full financial impact of closing Zion" apparently contain no allowance for incremental financing costs. GAO does suggest (on page 32 of the Zion report) that increased financing costs could result from closing Zion, and that such costs might be important.[1] But it then

[1] "Revenue requirements could be increased beyond our estimates if investors demand a higher risk premium on Commonwealth Edison's securities if Zion is closed prematurely. A relatively small increase in the interest rate on long-term bonds could greatly increase revenue requirements in future years, particularly when Commonwealth Edison's need for large amounts of capital for its new nuclear units is considered.

obscures the issue by indicating that such costs should not be counted because of uncertainty over whether the ICC would allow their inclusion in Commonwealth Edison's rate base.[2]

The uncertainty, then, may be less concerned with the existence of these costs than with who should bear them. But those are separate questions (although the distribution or responsibility for costs can easily affect their level). And GAO's decision to ignore these costs does not illuminate any of the underlying issues; it certainly does not allow them to present conservative, defensible cost estimates. By not including those costs in its estimates of total revenue requirements GAO underestimates, perhaps substantially, the total costs of closure, the revenue that Commonwealth Edison will require to remain viable, and the quantitative impacts that may be passed on to the ratepayers.

The uncertainty currently associated with the costs of prematurely closing nuclear power plants may well be represented by the GAO's range of $2 billion to $9 billion. More study on a number of issues is needed before we can accept any estimate with confidence. At least 6 areas can be identified at this time:

For example, a 1 percent increase in the interest rate on the $809 million in long-term financing planned for 1981 would amount to $8.1 million annually over the life of the security. Common stockholders could also demand a higher rate of return on their investment which, if granted, would further increase revenue requirements." (Zion report, pp. 32-33)

[2] "Any added costs due to higher interest rates or a higher rate of return on common stock will be heavily influenced by ICC decisions on how the costs of the Zion units would be treated in the rates if Commonwealth Edison is required to discontinue the Zion operations. Since there is no precedence for this kind of action, both ICC and investor responses are uncertain." (Zion report, p. 33)

- o The costing framework
- o Replacement power costs
- o Decommissioning costs
- o Incremental financing costs
- o Secondary or indirect costs
- o The distribution of the costs

Perhaps the most important need, at least initially, is for the development of a theoretical framework or perspective for costing power plant closures. Such a framework is needed if rational discussions are ever to be held on the future of the nuclear facilities.

GAO tries to cover all costs, but keeps returning to a conception of total revenue requirements. Revenue requirements may reflect all costs borne by the utility but they obviously cannot include costs borne by other entities. The initial prerequisite for a proper accounting of closure costs is erecting the proper framework within which all potential costs of closure can be discussed, evaluated, and compared. This framework must be based on the problem at hand, the actual policy decision that may be affected by the cost estimate. If the decision concerns the social benefits and costs of closing the power plant, then all costs are important no matter who initially incurs them or to whom they are ultimately passed. Other questions may require consideration of fewer types of costs.[3]

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[3] I am currently drafting a report that discusses a general perspective for analyzing power-plant closure costs. I hope to publish this work in several months as Nuclear Power Plant Closures: The Economic Issues. I view this perspective as quite broad and interesting: it includes the question of closing Indian Point and Zion; the question of opening (or closing) Diablo Canyon; the proposed abandonments before completion of Seabrook 2 and Units 4 and 5 of the Washing-

Replacement power costs clearly require careful treatment. They depend critically on the system within which the utility operates, and on the particular options that are available in a particular time and place. If replacement power for Indian Point must be generated within the New York City area due to transmission limitations, then those particular costs must be considered; and later those costs should be compared with the cost and feasibility of expanding the transmission facilities. On the other hand, if Commonwealth Edison must purchase power from members of MAIN, then the future expected costs of that power must be estimated from information on demand and supply conditions for the entire MAIN system. Estimates of replacement power costs will probably always need to be conducted by individual utilities or someone working directly for one of the utilities. But the work must be of the highest quality, and it must be fully documented if it is to be used in the public decision-making process.

Decommissioning costs also need to be looked at carefully since they could easily turn out to be much higher than we now believe. As GAO states, no major nuclear facilities the size of Zion or Indian Point have been decommissioned, so we have no actual cost experience. We do, though, have TMI; and the experience there is indicating that decommissioning may be a long, involved process, with costs increasing significantly with every delay and new regulatory ruling. TMI should provide

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ton Public Power Supply System's massive project; and, of course, the TMI case. Each of those cases involves billions of dollars; each involves the financial viability of at least one large utility; each involves several regulatory agencies (often operating at cross purposes); and each involves a high level of public interest (including many different representations of "the" public interest).

an excellent case history of the varieties, evolution, and causes of decommissioning costs.

Incremental financing costs may easily turn out to be the most important costs associated with forced closure of nuclear plants. It is helpful to differentiate between short-term and long-term financial effects. The immediate impact of closure would certainly be to reduce the profitability of the utility. Extra costs will be incurred and not all of them will be recouped through rate increases. And even if they were all ultimately found to be allowable costs, regulatory lag would still cause severe financial pressures for the utility.[4] The longer-term effect of closure, perhaps even more important, would be the obvious inference among investors that if one nuclear plant can be shut down they all can be. This would undoubtedly increase the financial risk, and the risk premiums demanded by investors, of all utilities.

Secondary or indirect costs will also be important if a nuclear facility is ever closed. Changes in operating and maintenance expenditures, construction and decommissioning costs, and the price of electricity will all induce secondary effects in the local community. Those in turn will induce further effects throughout the region. Secondary costs impact on social and economic groups other than the immediate stockholders, bondholders, and ratepayers of the utility. Currently, we know neither the magnitude of these effects nor who they will affect.

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[4] In the aftermath of the TMI accident, stock of the owning utility, General Public Utilities, fell from nearly $19 a share in 1979 to about $4.50. The company has lost the ability to borrow for cleanup (decommissioning) activities, activities that could cost nearly $1 billion.

Finally, the regional and socio-economic distribution of the costs (and benefits) is both highly uncertain and potentially quite sensitive politically. Voters in one region cannot be expected to support actions that benefit mainly consumers in other regions or producers in foreign countries. The distribution of effects is also highly interesting from an economic viewpoint because (1) each possible distribution will provide a different pattern of winners and losers among the user, supplier, and owner groups, (2) some distributions may affect the net level of closure costs, and (3) nearly all distributions will have serious implications for the future of the utility industry.

Each of these 6 areas contributes to the uncertainty currently associated with estimating closure costs for nuclear power plants. It is unlikely that any of these uncertainties will be resolved or significantly diminished in the near future, but each area needs to be directly addressed and the magnitude of its uncertainty at least quantified before rational decisions can be made concerning the future of nuclear electric facilities, whether the facility in question is called Zion, or TMI, or Diablo Canyon.

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APPENDIX: ESTIMATES OF INCREMENTAL REVENUE REQUIREMENTS FROM CLOSING ZION

GAO defines the incremental change in "total revenue requirements" for Commonwealth Edison from closing Zion as its total cost concept. It claims this concept "reflects the full financial impact of closing Zion."[1] Total revenue requirements are the sum of operating expenses, depreciation expense, taxes, interest, and return on investment.[2] The generating cost increases, discussed previously, represent the most immediate cost impact of shutting down the Zion units. Loss of the units, however, would also affect the other cost elements.

To investigate the effects of closure on the depreciation and return on investment items, GAO goes to great length adding and subtracting various specifications of those items to generating costs and displaying alternative estimates of revenue requirements. I discuss a number of the more interesting estimates below.

To allow for a range of possibilities, GAO looked at three cases:

> Case A calls for the removal of the unrecovered costs of the plant from the rate base so that no recovery of costs and no return on investment are allowed.
>
> Case B specifies the removal of Zion's costs from the rate base, but recovery of the costs is allowed through a 10 year write-off as depreciation expense.
>
> Case C specifies the inclusion of Zion's costs in the rate base so that a return on investment is allowed, and the utility is allowed to recover construction costs over the 10 year write-off period.

The estimates in Table A.1 indicate that with Zion removed from service, the revenue requirement increases for 1981 through 1986 would range from $47 million to $356 million, depending on the year and the

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[1] Ibid., p. 18.
[2] Ibid., p. 27.

Table A.1

GAO Estimates of Increases in Net Revenue Requirements With Zion Out of Service

(millions of dollars)

Year	1.5 percent load growth			3 percent load growth		
	A	B	C	A	B	C
1981	188	252	355	189	253	356
1982	146	211	303	140	204	296
1983	126	190	270	147	212	292
1984	90	154	221	136	200	268
1985	47	112	166	114	178	232
1986	92	156	196	178	242	282
Total	689	1075	1511	904	1289	1726

SOURCE: Zion report, Tables 19, 21, and 24.

NOTES: Detail may not sum to total due to rounding. Case A allows no write-off of plant or inclusion of plant costs in the rate base. Case B removes Zion from rate base but allows a 10-year write-off of plant cost. Case C allows both return on investment and 10-year write-off of plant.

assumptions used.[3] These estimates include allowance for the one-time savings that would accrue from not incurring the now-planned costs for plant additions, emergency planning, and chemical cleaning (costs that would not be incurred with Zion closed down), but do not include costs

[3] In constructing these estimates, GAO used revenue requirement projections for 1981 and the first half of 1982 that Commonwealth Edison had prepared for its current rate increase request. For subsequent periods, the estimates assume the completion of the company's current construction program and a 9 percent annual escalation of expense items. The rate of return on common equity--16.7 percent--was based on the recommendation of Commonwealth Edison's rate of return witness in recent rate hearings before the ICC. The changes in fuel costs with Zion out

for decommissioning and the disposal of spent fuel if Zion is closed.[4] Nor do they include the $13 million in property tax revenues that GAO estimates local governments would lose when Zion is closed.[5]

The estimates in Table A.1 also include only minor amounts for increased construction costs if Zion is closed. GAO finds that most increased revenue requirements resulting from increased production costs would be incurred beyond 1986.[6] To show the full impacts of those construction costs, GAO commissioned further study of long-run revenue requirements.

At GAO's request, Commonwealth Edison projected total revenue requirement increases through the year 2000, assuming the Zion units were taken out of service in 1981. Table A.2 shows the projections from this analysis, under the two alternate growth assumptions. In these projections, costs of the Zion plant are treated as sunk costs (depreciation expense and return on investment continue as they would with Zion in service) and decommissioning costs are included in 1984 revenue requirements. These projections, therefore, differ from the 1981-86 projections shown above in Table 3.

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of service are those projected using the production model. To account for State and local taxes on utility bills, expense items were increased by 9 percent to estimate the amount of revenue the utility must collect to recover its costs. Similarly, operating income was increased by 115 percent to account for utility revenue and income taxes used in determining revenue requirements. Revenue requirements were estimated using 3 and 1.5 percent load growth projections. The extent, if any, that Commonwealth Edison would be able to recover the cost of the Zion plant and earn a return on investment after the plant was closed would, of course, be determined by the Illinois Commerce Commission (ICC), the State agency that regulates utility rates. (Ibid., pp. 27-28)

[4] Ibid., p. 28.

[5] Ibid., p. 39. GAO also estimates that about 400 people who now work at Zion would be displaced by its closure.

[6] GAO finds that any new units constructed will cost substantially more than the units being replaced. The Zion units, constructed dur-

Table A.2

GAO Estimates of Increases in Total Revenue Requirements With Zion Out of Service

(millions of dollars)

Year	1.5-percent load growth	3-percent load growth
1981	$ 311	$ 312
1982	276	269
1983	262	283
1984	351	398
1985	188	254
1986	239	326
1987	246	409
1988	281	461
1989	338	467
1990	416	707
1991	499	1,100
1992	618	1,352
1993	819	1,359
1994	1,147	1,379
1995	1,406	1,379
1996	1,660	1,474
1997	1,867	1,429
1998	1,729	1,622
1999	2,023	1,417
2000	1,906	1,798
Total	$16,582	$18,194

SOURCE: Zion report, Table 28, page 37.
NOTE: Detail may not sum to total due to rounding.

GAO has, of course, some qualifications to the meaning of these projections also. But the estimates themselves reveal the essence of

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ing the late 1960's and early 1970's, have a cost of about $300 per kilowatt of capacity. For its long-term planning, Commonwealth Edison projects that generating capacity installed in the early 1990's will cost a minimum of $1,500 per kilowatt. Without Zion service dates for new units now tentatively planned for the 1990s would be accelerated 1 to 4 years depending on the load growth assumption. Closing Zion would eventually result in construction of 2,150 more MW of capacity than would otherwise be required. (Ibid., p. 36)

the GAO analyses. This table is reproduced in the text as Table 3 and is the basis of my derivation of an estimate for the "other costs" of closing Zion.

Table A.3 below reconciles GAO's estimates of production (generating) cost increases and its two concepts of revenue requirements. Note that although there is much adding and subtracting involved, the differences between the estimates are minor.

Table A.3

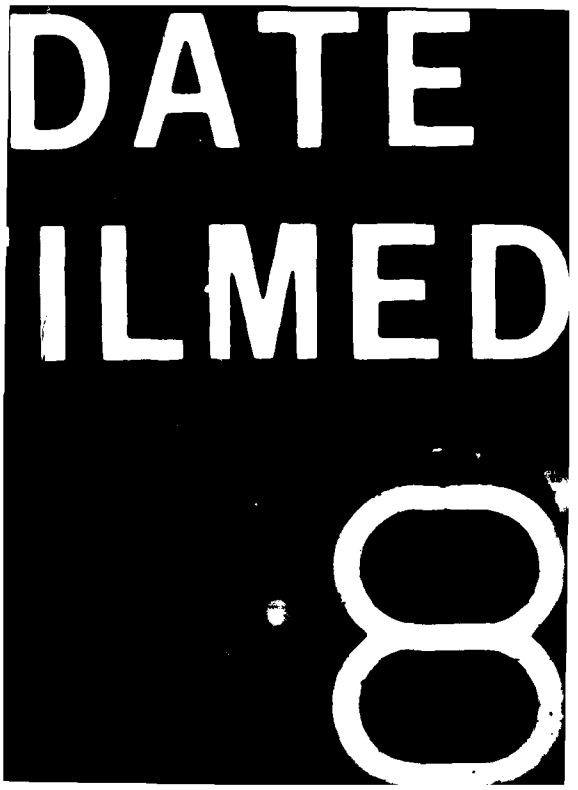
Reconciliation of Estimates of Incremental Revenue Requirements If Zion is Closed

(millions of dollars)

Item	1981	1982	1983	1984	1985	1986
Production cost increase	$313	$280	$294	$288	$268	$335
Add taxes on cost increase (a)	27	24	26	25	2.	29
Less decreases in real estate taxes, insurance, return on investment, and depreciation of plant (b)	-151	-164	-173	-177	-177	-186
Subtotal	$189	$140	$147	$136	$114	$178
Add allowance for 10-year write-off of Zion plant and fuel (b)	64	64	64	64	64	64
Subtotal	$253	$204	$212	$200	$178	$242
Add allowance for return on investment in Zion plant and fuel (b)	$103	$ 92	$ 80	$ 68	$ 54	$ 40
Total revenue requirement	$356	$296	$292	$268	$232	$282
Adjust Zion depreciation to historical rate rather than 10-year accelerated write-off, and include decommissioning costs in 1984	(44)	(27)	(9)	130	22	44
Long-term revenue requirement	$312	$269	$283	$398	$254	$326

SOURCE: Zion report, Tables 17-24, and 28.

NOTES: Detail may not sum to total due to rounding. (a) Calculated at 8.7 percent. (b) Including all applicable tax items. (c) Includes depreciation at historical rate rather than 10-year accelerated write-off, and decommissioning costs.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